REMARKS

Reconsideration and allowance of this application, as amended, is respectfully requested.

This amendment is in response to the Office Action dated September 10, 2003

By the present amendment, the Abstract has been amended to a single paragraph format and to contain less than 150 words. The Specification has also been reviewed and revised to correct the informalities noted on page 2 of the Office Action as well as other minor informalities noted in reviewing the Specification. To this end, a Substitute Specification is submitted herewith. The undersigned attorney hereby states that no new matter is presented by the Substitute Specification, as can be appreciated from the marked copy of the original Specification provided herewith to indicate where changes have been made.

With regard to the specific objection set forth on page 2 of the Office Action concerning the Specification, it is noted that the original page 6, lines 17 and 18 have been amended to define that the slider moves the container closer to the opener, as suggested in the Office Action. Also, the original page 7, line 17, and other locations, have been amended to change the word “cum” to “cam”, as suggested in the Office Action. The original page 10, line 12 has been amended to express the statement in question in a more idiomatic fashion. Finally, Fig. 5 has been amended by the present amendment to correlate with the description given on page 10. It is noted that no new matter is presented by the amending of Fig. 5 since it is being amended solely to properly correlate with the description on the original page 10, and further noting that the error in Fig. 5 would be obvious to those skilled in the art

when reading the Specification. In light of the amendments to the Abstract and Specification, reconsideration and removal of the objections set forth in the Office Action regarding the Specification and Abstract is respectfully requested.

Turning to the merits of the present invention, the present claims 1-5 define two different features of the present invention. The first of these features, defined, for example, by independent claims 1, 4 and 5, pertains to the specific setting of the operating velocity of opening a container to obtain a specific velocity-differential pressure ratio. In particular, as discussed in the Specification beginning at the bottom of the original page 2, the inventors discovered that conventional container opening/closing apparatuses used for semiconductor wafers suffer from a previously unrecognized problem pertaining to the velocity of opening the lid of a semiconductor containing which stores the semiconductor wafers. In particular, as noted at the beginning at the bottom of page 2 of the original Specification, the inside of the container is placed under a negative pressure at the time of opening the lid of the container due to the relatively high speed of opening the lid of the container. As noted on original page 3, lines 1-4:

> "As a result, foreign particles outside the container enter the container through the gap between the container and the container opening/closing apparatus, and the foreign particles adhere to the wafer."

It is noted that this discovery of the source of the problem of the foreign particles was previously unknown, and only realized based upon Applicants' careful study of this matter. For the Examiner's information regarding this, a copy is provided in the attached IDS of an article by the inventors entitled <u>Particle Characteristics of 300-MM Minienvironment</u> <u>(FOUP and LPU)</u>, Published in the IEEE Transactions On

Semiconductor Manufacturing, Vol. 13, No. 3, August 2000. The inventors were invited to write this article based upon the significance of their discovery of this problem caused by the high opening speed of the lid of the semiconductor container which contains the wafers.

Based upon their further studies, the inventors arrived at a particular velocity-differential pressure ratio in order to minimize the number of particles on a wafer caused by this previously unknown problem. To this end, Applicants arrived at the discovery that if the velocity-differential pressure ratio (obtained by dividing the maximum velocity at the time of opening the lid of the container by the differential pressure between the inside pressure and the outside pressure) is set to 0.06 (m/s) Pa or less, the particle problem could be significantly decreased. This feature is defined in each of the independent claims 1, 4 and 5.

A second feature of the present invention is discussed, for example, beginning with the first full paragraph on page 14 of the original Specification. As noted there, conventional safety covers used in opening/closing devices only provide an opening at the upper end portion. Through their studies, Applicants have discovered that this leads to a problem of foreign particles, generated by the opener or the opener elevator mechanism, being trapped inside the safety cover. These foreign particles can undesirably find their way into the container to adhere to the wafer when the opener elevator mechanism moves downward. Accordingly, as discussed on pages 14 and 15 of the Specification, another feature of the present invention is to provide an opening at the bottom of the safety cover 140. This prevents foreign particles from being deposited inside the safety cover. As noted beginning on the last line of page 14 of the original Specification:

> "Therefore, the number of foreign particles adhering to the wafer 300 stored in the container 200 can be reduced, and thus the yield of the semiconductor component can be improved." This feature is defined in claims 2 and 3 of the application.

Reconsideration an removal of the 35 U.S.C. § 103 rejection of claims 1 and 4 as being unpatentable over U.S. Patent 6,281,561 to Bacchi is respectfully requested. As noted above, each of the independent claims 1 and 4 contain the specific limitation regarding the setting of the operating velocity of opening the container to obtain a specific velocity-differential ratio. In particular, the operating velocity is set to obtain a velocity-differential pressure ratio of 0.06 ((m/s)Pa) or less. As discussed above, and as described in the Specification, the setting of the operating velocity to obtain this velocity-differential pressure ratio is an important feature for significantly reducing the amount of foreign particles drawn into the semiconductor container and adversely adhering to the semiconductor wafers contained therein.

In the Office Action, it is recognized on page 4, line 6 that "Bacchi does not teach any specific speed for opening the carrier door." However, the Office Action goes on to state:

> "However, based upon the design constraints of the system and the knowledge of the rate of deposited debris as discussed above it would have been obvious to one of ordinary skill in the art, at the time of invention to choose a speed for opening the wafer carrier that allows the wafer to remain above a predetermined level of cleanliness based upon the pressure differentials between the process device and the ambient air."

Applicants respectfully submit that this line of reasoning set forth in the Office Action is effectively the same type of "obvious to try" rational held to be unacceptable by the

CCPA in the case of In re Antonie, 195 USPQ 6 (CCPA 1977) and by the CAFC in the case of In re Fine, 5 USPQ 2d 1596 (Fed. Cir. 1988). In the case of In re Antonie, the CCPA stated:

> "The PTO and the minority appear to argue that it would always be obvious for one of ordinary skill in the art to try varying every parameter of a system in order to optimize the effectiveness of the system even if there is no evidence in the record that the prior art recognized that particular parameter affected the result. As we have said many times, obvious to try is not the standard of 35 U.S.C. § 103...Disregard for the unobviousness of the results of "obvious to try" experiments disregards the "invention as a whole" concept of section 103." [emphasis by court], 195 USPQ at 8.

The CAFC affirmed this same principle in the case of In re Fine in stating:

> "Because neither Warnick nor Eads, alone or in combination, suggests the claimed invention, the Board erred in affirming the Examiner's conclusion that it would have been obvious to substitute the Warnick nitric oxide detector for the Eads sulfur dioxide detector in the Eads system...The Eads and Warnick references disclose, at most, that one skilled in the art might find it obvious to try the claimed invention. But whether a particular combination might be "obvious to try" is not a legitimate test of patentability." 5 USPQ 2d at 1599.

It is urged that, in the present instance, the Office Action is using the same "obvious to try" approach prohibited by the Antoni and Fine cases. As noted above, the Offices Action recognizes that Bacchi does not teach any specific speed for opening the carrier door. However, the Office Action goes on to state that one of ordinary skill in the art could "choose a speed for opening the wafer carrier that allows the wafer to remain above a predetermined level of cleanliness based on the pressure differentials." In other words, the Office Action regards it as obvious for one to try selecting a variety of speeds until a satisfactory result is achieved. This falls squarely within the prohibition against the "obvious to try" rational.

More recently, the CAFC set forth a similar holding in the case of In re Lee, 61 USPQ 1430. In this case, the Court addressed a proposed combination and modification of references based on

> "the Examiner's conclusury statements that "the demonstration mode is just a programmable feature which can be used in many different devices for providing automatic introduction by adding the proper programming software" and that "another motivation would be that the automatic demonstration mode is user friendly and it functions as a tutorial.""

The similarity to the present rejection is noted since, in the present instance, a similar rational is set forth in the Office Action that one skilled in the art could readily arrive at an appropriate speed. In response to the Patent Office position in the case of In re Lee, the CAFC stated:

> "This factual question of motivation is material to patentability, and could not be resolved on subjective belief and unknown authority. It is improper, in determining whether a person of ordinary skill in the art would have been lead to this combination of references, simply to "use that which the inventor taught against its teacher."

It is respectfully submitted that the statement in the Office Action that it would be obvious for one of ordinary skill in the art "to choose a speed for opening the wafer carrier that allows the wafers to remain at a predetermined level of cleanliness based upon the pressure differentials" is precisely the kind of statement of "subjective belief and unknown authority" prohibited by the In re Lee decision. Accordingly, based upon the above noted holdings of the CCPA and CAFC, reconsideration and removal of the rejection of claims 1 and 4 in this application is earnestly solicited.

Reconsideration and allowance of claims 2 and 3 over the combination of Bacchi and Donora is also respectfully required. As discussed above, claims 2 and

3 define the second feature of the present invention in providing an opening at a lower end portion of the cover. In particular, as defined in the amended claim 2, this feature has been set forth in a means plus function format of:

> "means for preventing particles generated by operation of the opener and opener elevator mechanism from being trapped in the cover, said means including an opening provided at a lower end portion of said cover in the rear side of said semiconductor container opening/closing apparatus."

Defining the invention in terms of means plus function format is specifically permitted by 35 U.S.C. § 112, sixth paragraph. Also, as set forth by the CAFC in the case of In re Donaldson, 29 USPQ 2d 1845, such means plus function language must be given the same weight as structural limitations. With regard to this, it is submitted that neither Bacchi nor Bonora teach or suggest any "means for preventing particles generated by operation of the opener and the opener elevator mechanism from being trapped in the cover." As set forth in the Office Action, the Bonora reference teaches a fan 48 located in a cover mechanism. However, there is no discussion in Bonora recognizing using such a structure in combination with an opening for obtaining the claimed function of preventing particles generated by operation of the opener and opener elevator mechanism from being trapped in the cover. On the contrary, the only motivation for such a modification lies within Applicants' own teachings. As such, this rejection of claims 2 and 3 also falls within the prohibition set forth in the In re Lee decision that "it is improper, in determining whether a person of ordinary skill would have been lead to this combination of references, simply to "use that which inventor taught against its teacher.", 61 USPQ 2d at 1434.

Accordingly, reconsideration and allowance of amended claim 2 and its dependent claim 3 is also requested.

Finally, reconsideration and allowance of newly submitted claim 5 over the cited prior art is also respectfully requested. Claim 5 defines the above-noted first feature of the invention in means plus function format throughout. In particular, claim 5 ends with the limitation of "means for preventing foreign particles being drawn into said semiconductor container during opening of said lid, said means comprising means for setting an operating velocity of opening the container." Claim 5 goes on to define the same specific feature of setting the operating velocity to obtain the velocity-differential pressure ratio of 0.06((m/s) Pa) or less, as set forth in claims 1 and 4.

As such, claim 5 defines a means plus function limitation which is completely lacking from the Bacchi reference. As recognized in the Office Action, Bacchi fails to teach controlling the operating velocity of the opening of the container for any reason. As such, it is completely inappropriate to stretch this reference to try to meet a limitation of the means plus function language of means for preventing foreign particles from being drawn into the semiconductor container based on controlling the opening velocity in the manner defined by claim 5. Therefore, reconsideration and allowance of this newly submitted claim 5 is also respectfully requested.

For the reasons set forth above, it is respectfully submitted that claims 1-5 clearly define over the cited prior art in the Office Action, and reconsideration and allowance of these claims is earnestly solicited.

If the Examiner believes that there are any other points which may be clarified or otherwise disposed of either by telephone discussion or by personal interview, the

Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Antonelli, Terry, Stout & Kraus, LLP Deposit Account No. 01-2135 (Docket No. 843.4117X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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Application No.: 10/031,785

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FEB 06 2004
PATENT & TRADEMARK OFFICE

Docket No.: 843.41117X00

APPENDIX A

Fig. 5

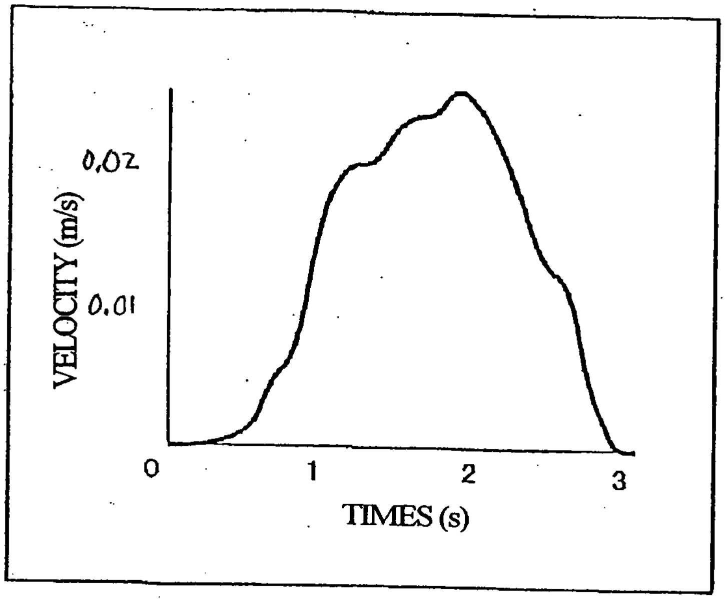
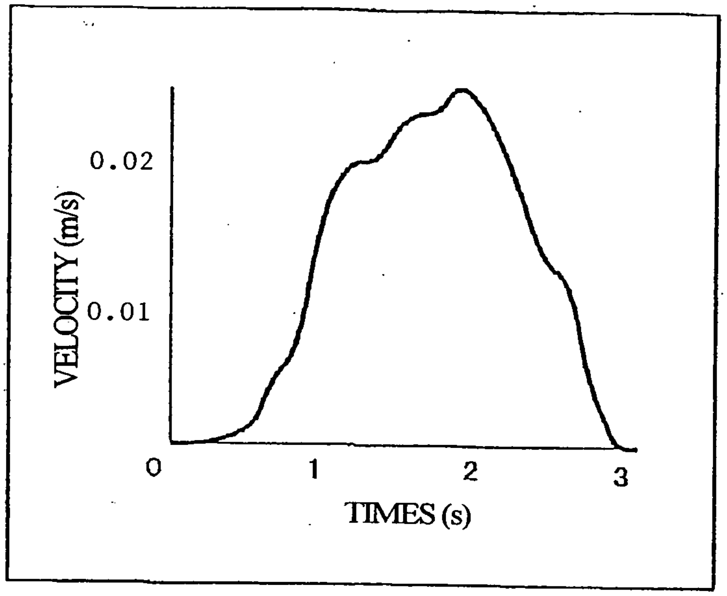


Fig. 5



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APPENDIX B

Substitute Specification

SEMICONDUCTOR CONTAINER OPENING/CLOSING APPARATUS AND SEMICONDUCTOR DEVICE MANUFACTURING METHOD

TECHNICAL FIELD OF THE INVENTION

[0001] The present invent ion relates to a semiconductor container opening/closing apparatus, which opens and closes a lid of a semiconductor wafer container used in a semiconductor manufacturing process, and more particularly relates to a semiconductor device manufacturing method in which the semiconductor container opening/closing apparatus is installed in each semiconductor manufacturing apparatus and a semiconductor wafer is conveyed using the semiconductor wafer container.

BACKGROUND OF THE INVENTION

[0002] Recently, in semiconductor manufacturing plants, semiconductor wafers are conveyed between each manufacturing apparatus while being stored in semiconductor containers (hereinafter, referred to as a container) with a lid that isolates the semiconductor wafers from the outer environment. The inside of the container is kept in a very clean condition in comparison to the outside and only a small number of foreign particles are adhered to the wafer inside the container if the lid of the container is not opened. The condition outside the container is the ISO cleanliness level 6 or the like, and if the wafer is left in such a condition, over time the foreign particles are adhered to a surface of the wafer. Consequently, the yield of

a semiconductor component formed on the wafer is significantly decreased. The container opening/closing apparatus is provided in each manufacturing apparatus, and the inside of the manufacturing apparatus is kept in a very clean condition in comparison to the outside, that is, the ISO cleanliness level 1 to 2.

[0003] When the wafer is conveyed from the container to the manufacturing apparatus or from the manufacturing apparatus to the container, the manufacturing apparatus and the container are first connected to each other via the container opening/closing apparatus. Next, the lid of the container is opened, and thereby it is possible to directly connect the clean area inside the manufacturing apparatus and the clean area inside the container. Therefore, there is little possibility that the wafer is exposed to the outside air.

[0004] The velocity of opening the lid of the container in the conventional container opening/closing apparatus is set high in order to reduce the operating time. Also, the conventional container opening/closing apparatus is provided with a safety cover that covers a driving system in the rear side of the apparatus. As a result, the lower end portion of this safety cover has a closed structure.

[0005] Conventional container opening/closing apparatuses have suffered from the following problem. That is, since the velocity of opening the lid of the container is high, the inside of the container is under negative pressure at the time of opening the lid of the container. As a result, foreign particles outside the container enter the container through the gap between the container and the container opening/closing apparatus, and the foreign particles adhere to the wafer.

[0006] In addition, another problem also exists in the conventional container opening/closing apparatus. That is, since a safety cover is provided for the

conventional container opening/closing apparatus to cover the driving system in the rear side thereof, and since the lower end portion of the safety cover has a closed structure, foreign particles are deposited inside the safety cover. These foreign particles are blown out when a lid elevator unit moves downward, and then enter the container to adhere to the wafer.

[0007] An object of the present invention is to reduce the number of foreign particles adhering to a wafer by preventing the foreign particles from entering the container at the time of opening the container using the container opening/closing apparatus.

[0008] Also, another object of the present invention is to reduce the number of foreign particles adhering to a wafer by preventing the foreign particles from being deposited inside the safety cover and preventing the foreign particles from being blown out.

DISCLOSURE OF THE INVENTION

[0009] For the achievement of the above objects, the semiconductor container opening/closing apparatus and a method of opening and closing a lid of the semiconductor wafer container according to the present invention are characterized in that a velocity-differential pressure ratio obtained by dividing the maximum velocity (m/s) at the time of opening the semiconductor container, by the differential pressure (Pa) between the inside pressure and the outside pressure •of the semiconductor manufacturing apparatus, is set to be 0.006 ((m/s)/Pa) or less.

[0010] Also, the semiconductor container opening/closing apparatus according to the present invention is characterized in that an opening is provided at a

lower end portion of the cover in the rear side of the semiconductor container opening/closing apparatus.

[0011] Also, the semiconductor container opening/closing apparatus according to the present invention is characterized in that an exhaust fan is provided at a lower end portion of the cover in the rear side of the semiconductor container opening/closing apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a perspective view of a semiconductor container opening/closing apparatus according to a first embodiment of the present invention, Fig. 2 is a perspective view of a semiconductor container, Fig. 3 is a perspective view of a semiconductor manufacturing apparatus in which semiconductor container opening/closing apparatuses according to a first embodiment of the present invention are installed, Fig. 4 is a conceptual graph showing the correlation between the maximum velocity of opening the semiconductor container and the number of foreign particles adhering to a wafer, Fig. 5 is a conceptual view showing, relative to change of time, the velocity of opening the container by the semiconductor container opening/closing apparatus according to a first embodiment of the present invention, Fig. 6 is a conceptual graph showing, relative to change of time, the velocity of opening the container by the conventional semiconductor container opening/closing apparatus, Fig. 7 is a conceptual graph showing the correlation between the maximum velocity of opening the semiconductor container and the number of foreign particles adhering to a wafer, and Fig. 8 is a conceptual graph showing the

correlation between the maximum velocity of opening the semiconductor container and the number of foreign particles adhering to the wafer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] For a more detailed description of a first embodiment of the present invention, the first embodiment will be described based on the accompanying drawings (Figs * 1 to 8).

[0014] Fig. 1 is a perspective view of a semiconductor container opening/closing apparatus (hereinafter, referred to as an opening/closing apparatus) according to the first embodiment of the present invention, Fig. 2 is a perspective view of a semiconductor container (hereinafter, referred to as a container), Fig. 3 is a perspective view of a semiconductor manufacturing apparatus (hereinafter, referred to as a manufacturing apparatus) in which the opening/closing apparatuses are installed, Figs. 4, 7, and 8 are conceptual graphs each showing the correlation between the maximum velocity of opening the container and the number of foreign particles adhering to a wafer, Fig. 5 is a conceptual graph showing, relative to change of time, the velocity of opening the container by the opening/closing apparatus according to the first embodiment of the present invention, and Fig. 6 is a conceptual graph showing, relative to a change of time, the velocity of opening the container by the conventional opening/closing apparatus.

[0015] Descriptions will be first made of respective structures of an opening/closing apparatus 100 and a container 200 by using Figs. 1 and 2. The opening/closing apparatus 100 is mainly constituted by a stage 110 for placing the container 200, and an opener 120 for holding a lid 220 of the container 200 and for

opening and closing the lid 220. The stage 110 is provided with positioning pins 112 for placing the container 200 in a proper position, and a slider ill for bringing the container 200 closer to an opener 120. In this embodiment, the slider 111 is movable back and forth by a motor and a ball screw (not shown) provided in the stage 110. Rotating keys 121 are provided on the opener 120, and the rotating keys 121 can rotate up to 90 degrees by a motor (not shown) provided in the opener 120. In the rear side of the opener 120, an opener opening/closing mechanism 130 for opening and closing the lid 220 of the container 200 by making the opener 120 move back and forth horizontally, and an opener elevator mechanism 131 for moving the opener 120 up and down are provided. Both of the opener opening/closing mechanism 130 and the opener elevator mechanism 131 are operated by a motor and a ball screw (not shown), and a safety cover 140 is provided on the whole of both driving units of the opener opening/closing mechanism 130 and the opener elevator mechanism 131 so that an operator(s) can not touch them easily.

[0016] The container 200 is constituted by a container body 210 and the lid 220. The container body 210 is provided with four latch grooves 211, and a flange 212 is provided around the container body 210. A shelf (not shown) is provided inside the container body 210 for storing wafers 300 horizontally, and twenty-five wafers can be stored therein. Key grooves 221 are provided on the lid 220 at positions corresponding to those of the rotating keys 121 of the opening/closing apparatus 100. The rotating keys 121 of the opening/closing apparatus 100 are inserted into the key grooves 221 and rotated by 90 degrees. By virtue of this, four latches 222 in the lid 220 come in and out from the lid 220 by a cam mechanism (not shown) operating• inside the lid 220. The latches 222 are at positions corresponding

to those of the latch grooves 211 of the container body 210, and when the latches 222 come out from the periphery of the lid 220 while the lid 220 is inserted in the container body 210, the lid 220 can be fixed to the container body 210.

[0017] The actual operation of opening the container 200 is carried out as follows. The container 200 is placed on the stage 110. The slider 111 on the stage 110 is moved horizontally toward the manufacturing apparatus, and a surface of the lid 220 of the container 200 and the opener 120 of the opening/closing apparatus 100 are contacted to each other. At this time, though the flange 212 of the container 200 and a surface board 150 of the opening/closing apparatus 100 are partly contacted to each other, a gap is inevitably left therebetween due to the process accuracy of the container 200. When the rotating keys 121 are rotated by 90 degrees in the clockwise direction toward the container 200 while the lid 220 and the opener 120 are contacted to each other, the key grooves 221 of the lid 220 are rotated and the lid 220 is fixed to the opener 120. Simultaneously, the latches 222 are accommodated inside the lid 220 by a function of the cam mechanism (not shown) inside the lid 220. Thereafter, the opener opening/closing mechanism 130 is horizontally moved toward the manufacturing apparatus to detach the lid 220 of the container 200 from the container body 210. Specifically, the lid 220 of the semiconductor container 200 is held and opened in a direction vertical to an opening surface of the container 200. Then, the opener 120 is moved downward by the opener elevator mechanism 131.

[0018] The operation of closing the container 200 is carried out in a reverse manner to the operation of opening the same, in which, after the opener elevator mechanism 131 is moved upward, the opener opening/closing mechanism

130 is moved horizontally toward the stage 110 to connect, to the container body 210, the lid 220 fixed to the opener 120. Thereafter, when the rotating keys 121 are rotated by 90 degrees in the counterclockwise direction, the latches 222 of the lid 220 are fit into the latch grooves 211 on the container body 210. Thus, the lid 220 is fixed to the container body 210. Finally, the slider 111 is moved horizontally in a direction opposite to the manufacturing apparatus, and, thereby, the container 200 is put into a state where it can be detached from the stage 110.

[0019] Fig. 3 shows an example where four opening/closing apparatuses 100 are mounted to a manufacturing apparatus 400. Downflow is formed inside the manufacturing apparatus 400, and the inside of the apparatus 400 is kept in the ISO cleanliness level 1 to 2, that is, the inside thereof is kept in a very clean condition in comparison to the outside of the manufacturing apparatus 400 which is in the ISO cleanliness level 6. If a wafer is left in the environment of the ISO cleanliness level 6, over time foreign particles adhere to a wafer surface. As a result, the yield of semiconductor components formed on the wafer is significantly decreased. The inside of the container 200 is shielded from the outside thereof, and if the wafer 300 is loaded and unloaded in the high-cleanliness environment, the cleanliness inside the container is maintained. Therefore, even if the container 200 is left in the environment of the ISO cleanliness level 6, only a small number of foreign particles adhere to the wafer 300 inside the container 200 unless the lid 220 of the container 200 is opened or closed.

[0020] When the wafer 300 is moved from the container 200 to the manufacturing apparatus 400 or from the manufacturing apparatus 400 to the container 200, the lid 220 of the container 200 is opened or closed after connection

of the manufacturing apparatus 400 and the container 200 via the container opening/closing apparatus 100. Thus, a clean area inside the manufacturing apparatus 400 and a clean area inside the container 200 are directly connected to each other. Since the pressure inside the manufacturing apparatus 400 is set to a slightly positive pressure in comparison to the outside thereof, there is little possibility that the foreign particles will flow through the gap between the flange 211 of the container 200 and the surface board 150 of the opening/closing apparatus 100, except at the moment of opening or closing the container 200.

[0021] If the operating velocity of the opener opening/closing mechanism 130 of the opening/closing apparatus 100 is high, then the inside of the container 200 experiences a negative pressure at the time of pulling out the lid 220 from the container body 210, and the foreign particles enter into the container 200 through the gap between the flange 211 of the container 200 and the surface board 150 of the opening/closing apparatus 100, and adhere to the wafer 300.

[0022] Fig. 5 shows, relative to the change with time, the velocity of opening the container 200 by the opener opening/closing mechanism 130 of the opening/closing apparatus 100 according to the present invention. In Fig. 5, the horizontal axis represents time (s) and the vertical axis represents the velocity of opening (m/s), and the maximum velocity is 0.025 (m/s). Fig. 6 shows, relative to the change with time, the velocity of opening the container 200 by the opener opening/closing mechanism 130 of the conventional opening/closing apparatus 100. In Fig. 6, the horizontal axis represents time (s) and the vertical axis represents the velocity of opening (m/s), and the maximum velocity is 0.15 (m/s).

[0023] Fig. 4 is a conceptual graph showing the correlation between the maximum velocity of opening the container and the number of foreign particles adhering to a wafer stored •in the container when the inside pressure of the apparatus 400 is higher by 1 (Pa) than the pressure of the outside. In Fig. 4, the horizontal axis represents the maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130, and the vertical axis represents the number of foreign particles (Number/WaferTimes) which have a grain size of 0.12 pm or more and which adhere to the uppermost wafer 300 stored in the container 200 per opening/closing of the container 200. Fig. 7 is a conceptual graph showing the correlation between the maximum velocity of opening and closing the container and the number of foreign particles adhering to a wafer when the inside pressure of the apparatus 400 is higher by 5 (Pa) than the pressure of the outside. The vertical and horizontal axes of Fig. 7 represent the same variables as those of Fig. 4. Fig. 8 shows a conceptual graph showing the correlation between the maximum velocity of opening and closing the container and the number of foreign particles adhered to a wafer when the inside pressure of the apparatus 400 is higher by 10 (Pa) than the pressure of the outside. The vertical and horizontal axes of Fig. 8 represent the same variables as those of Figs. 4 and 7.

[0024] In Fig. 4, the number of foreign particles adhering to the wafer 300 exceeds 0.01 (Number/WaferTimes) at the maximum velocity of 0.06 (m/s), and it rapidly increases if the maximum velocity is over 0.06 (m/s). In Fig. 7, the number of foreign particles exceeds 0.01 (Number/WaferTimes) at the maximum velocity of 0.3 (m/s), and in Fig. 8, the number of foreign particles exceeds 0.01 (Number/WaferTimes) at the maximum velocity of 0.& (m/s). As is apparent from

Figs. 4, 7, and 8, it can be understood that the maximum velocity, at which the number of foreign particles increases, becomes higher in proportion to the differential pressure between the inside pressure and the outside pressure of the apparatus 400.

[0025] The number of foreign particles adhering to the wafer 300 can be reduced by decreasing the maximum velocity of opening of the container by the opener opening/closing mechanism 130. However, the slow operating velocity in each unit of the opening/closing apparatus 100 influences the process faculty of the manufacturing apparatus 400 per unit time. Therefore, it is required to set the operating velocity in an appropriate range. For this reason, it is conceived that the operating velocity should be set in a certain range capable of- sufficiently assuring the operation ability of the semiconductor manufacture, and also be set lower than the operating velocity at which the number of foreign particles is 0.01 (Number/WaferTimes), which is a boundary at which the number of foreign particles adhering to the wafer begins to rapidly increase in all of Figs. 4, 7, and 8. Since the differential pressure between the inside pressure and the outside pressures of the apparatus 400 is proportional to the maximum velocity at which the number of foreign particles begins to increase, the number of foreign particles adhering to the wafer surface can be suppressed by setting a ratio (velocity-differential pressure ratio Dvp) between the Vmax: maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130 and APa: differential pressure (Pa) between the inside pressure of the apparatus 400 and the outside pressure so as to satisfy the formula I shown below:

$$Vmax/APa = Dvp \sim 0.06,$$

where APa: differential pressure (Pa) between the inside pressure of the apparatus 400 and the outside pressure, Vmax: maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130, and Dvp: velocity-differential pressure ratio (m/sPa).

[0026] In this embodiment, since the velocity-differential pressure ratio is within the range defined by formula 1, the number of foreign particles adhering to the wafer 300 stored in the container 200 can be reduced. Therefore, the yield of the semiconductor component can be improved.

[0027] Note that this embodiment is an example where the condition outside the container is in the ISO cleanliness level 6, and the number of foreign particles adhering to the wafer changes depending on changes in the surrounding condition. However, the maximum velocity at which the number of foreign particles adhering to the wafer begins to rapidly increase is always constant.

[0028] By providing a packing at a contact position between a surface plate 150 of the opening/closing apparatus 100 and a flange 212 of the container 200, and by filling the gap between the surface plate 150 and the flange 212, the foreign particles which enter into the container at the time of opening the lid 220 of the container 200 are shut out. Thus, the number of foreign particles adhering to the wafer 300 can be reduced. If the packing is provided, however, the following problems are created. That is, one problem is that the packing itself generates dust due to the deterioration caused by the change with time and to repetitive use of the packing. Thus, there is an increase in the number of foreign particles adhering to the wafer. Another problem is that the cost is increased due to the additional cost required to provide the packing itself, to process the surface plate, and to install the

packing. Since the packing is not required in this embodiment, the reliability is high and the cost is low.

[0029] Also, in another embodiment (second embodiment) of the present invention, an opening is provided at a lower end portion of the safety cover 140 of the opening/closing apparatus 100. In the conventional safety cover 140, the opening is provided at only the upper end portion of the safety cover. Therefore, a problem has arisen that the foreign particles generated from the opener opening/closing mechanism 130, the opener elevator mechanism 131, or the like are deposited inside the safety cover 140. As a result, the deposited foreign particles are blown out at the time when the opener elevator mechanism 131 moves downward, and enter the container 200 and adhere to the wafer. In this embodiment, since the opening is provided at the lower end portion of the safety cover 140, the foreign particles are not deposited inside the safety cover and are not blown out. Therefore, the number of foreign particles adhering to the wafer 300 stored in the container 200 can be reduced, and thus the yield of the semiconductor component can be improved.

[0030] The safety cover 140 covers the driving systems of the opener opening/closing mechanism 130 and the opener elevator mechanism 131 in order to ensure safety of an operator and to protect the driving systems at the time of conveying the opening/closing apparatus 100. Therefore, even if the opening is provided at the lower end portion of the safety cover 140, the safety cover does not lose its essential function.

[0031] Also, in this embodiment, the opening is simply provided at the lower end portion of the safety cover 140. However, the same effect can be expected by providing an exhaust fan at the lower end portion of the safety cover 140.

INDUSTRIAL APPLICABILITY

[0032] As described above, according to the present invention, it is possible to reduce the number of foreign particles entering into the container at the time of opening the container, and, therefore, the number of foreign particles adhering to the wafer can be reduced and the yield of the semiconductor component can be improved. In addition, since a packing is not required, an opening/closing apparatus having high reliability can be realized at low cost.

[0033] Also, according to the present invention, since the foreign particles are not deposited inside the safety cover, the foreign particles are not blown out, and, thus, the number of foreign particles adhering to the wafer can be reduced. Therefore, the yield of the semiconductor component can be improved.

ABSTRACT OF THE DISCLOSURE

When a conventional semiconductor container opening/closing apparatus opens a lid of a semiconductor container, foreign particles enter into the container from outside through a gap between the container and a wall surface of the container opening/closing apparatus and adhere to a wafer in the container. An apparatus is provided to reduce the number of foreign particles adhering to the wafer by preventing foreign particles from entering into the container at the time of opening the container by the opening/closing apparatus. To achieve this, a velocity-differential pressure ratio obtained by dividing the maximum velocity at the time of opening the lid of the container in a vertical direction to an opening of the container, by the differential pressure between the inside pressure and the outside pressure of said semiconductor manufacturing apparatus, is set to be 0.06 ((m/s) Pa) or less.

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SPECIFICATION

TITLE OF THE INVENTION

SEMICONDUCTOR CONTAINER OPENING/CLOSING APPARATUS

AND

SEMICONDUCTOR DEVICE MANUFACTURING METHOD

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a semiconductor container opening/closing apparatus, which opens and closes a lid of a semiconductor wafer container used in a semiconductor manufacturing process, and more particularly relates to a semiconductor device manufacturing method in which the semiconductor container opening/closing apparatus is installed in each semiconductor manufacturing apparatus and a semiconductor wafer is conveyed using the semiconductor wafer container.

BACKGROUND OF THE INVENTION

Recently, in ~~a~~ semiconductor manufacturing plan~~t, a~~ts semiconductor wafer~~ is~~s are conveyed between each manufacturing apparatus while being stored in ~~a~~ semiconductor containers (hereinafter, referred to as a container) with a lid that isolates the semiconductor wafers from the outer environment. The inside of the container is kept in a very clean condition in comparison to the outside and only a small number of foreign particles are adhered to the wafer inside the container if the lid of the container is not opened. The condition outside the container is the ISO cleanliness level 6 or the like, and if

the wafer is left in such a condition, over time the foreign particles are adhered to a surface of the wafer ~~with time~~. Consequently, the yield of a semiconductor component formed on the wafer is significantly decreased. The container opening/closing apparatus is provided in each manufacturing apparatus, and the inside of the manufacturing apparatus is kept in a very clean condition in comparison to the outside, that is, the ISO cleanliness level 1 to 2.

When the wafer is conveyed from the container to the manufacturing apparatus or from the manufacturing apparatus to the container, the manufacturing apparatus and the container ~~is~~ are first connected to each other via the container opening/closing apparatus. ~~and then~~ Next, the lid of the container is opened, and thereby it is possible to directly connect the clean area inside the manufacturing apparatus and the clean area inside the container. Therefore, there is little possibility that the wafer is exposed to the outside air.

The velocity of opening the lid of the container in the conventional container opening/closing apparatus is set high in order to reduce the operating time. Also, the conventional container opening/closing apparatus is provided with a safety cover that covers a driving system in the rear side of the apparatus. ~~and so~~ as a result, the lower end portion of this safety cover has a closed structure.

There has been a problem as follows in the conventional container opening/closing apparatus. es have suffered from the following problem. That is, since the velocity of opening the lid of the container is high, the inside of the container is under negative pressure at the time

of opening the lid of the container. As a result, foreign particles outside the container enter the container through the gap between the container and the container opening/closing apparatus, and the foreign particles adhere to the wafer.

In addition, ~~there has been~~ another problem also exists ~~as follows~~ in the conventional container opening/closing apparatus. That is, since a safety cover is provided ~~to~~ for the conventional container opening/closing apparatus ~~so as~~ to cover the driving system in the rear side thereof, and since the lower end portion of the safety cover has a closed structure, foreign particles are deposited inside the safety cover. ~~and~~ These foreign particles are blown out ~~at the time~~ when a lid elevator unit moves downward, and then enter the container to adhere to the wafer.

An object of the present invention is to reduce the number of foreign particles adhering to a wafer by preventing the foreign particles from entering the container at the time of opening the container using the container opening/closing apparatus.

Also, another object of the present invention is to reduce the number of foreign particles adhering to a wafer by preventing the foreign particles from being deposited inside the safety cover and preventing the foreign particles from being blown out.

DISCLOSURE OF THE INVENTION

For the achievement of the above objects, the semiconductor container opening/closing apparatus and a method of opening and closing a lid of the semiconductor wafer

container according to the present invention are characterized in that a velocity-differential pressure ratio obtained by dividing the maximum velocity (m/s) at the time of opening the semiconductor container, by the differential pressure (Pa) between the inside pressure and the outside pressure of the semiconductor manufacturing apparatus, is set to be 0.006 ((m/s)/Pa) or less.

Also, the semiconductor container opening/closing apparatus according to the present invention is characterized in that an opening is provided at a lower end portion of the cover in the rear side of the semiconductor container opening/closing apparatus.

Also, the semiconductor container opening/closing apparatus according to the present invention is characterized in that an exhaust fan is provided at a lower end portion of the cover in the rear side of the semiconductor container opening/closing apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a semiconductor container opening/closing apparatus according to a first embodiment of the present invention, Fig. 2 is a perspective view of a semiconductor container, Fig. 3 is a perspective view of a semiconductor manufacturing apparatus in which semiconductor container opening/closing apparatuses according to a first embodiment of the present invention are installed, Fig. 4 is a conceptual graph showing the correlation between the maximum velocity of opening the semiconductor container and the number

of foreign particles adhering to a wafer, Fig. 5 is a conceptual view showing, relative to change of time, the velocity of opening the container by the semiconductor container opening/closing apparatus according to a first embodiment of the present invention, Fig. 6 is a conceptual graph showing, relative to change of time, the velocity of opening the container by the conventional semiconductor container opening/closing apparatus, Fig. 7 is a conceptual graph showing the correlation between the maximum velocity of opening the semiconductor container and the number of foreign particles adhering to a wafer, and Fig. 8 is a conceptual graph showing the correlation between the maximum velocity of opening the semiconductor container and the number of foreign particles adhering to the wafer.

DESCRIPTION OF THE PREFFERRED EMBODIMENTS

For a more detailed description of a first embodiment of the present invention, the first embodiment will be described based on the accompanying drawings (Figs. 1 to 8).

Fig. 1 is a perspective view of a semiconductor container opening/closing apparatus (hereinafter, referred to as an opening/closing apparatus) according to the first embodiment of the present invention, Fig. 2 is a perspective view of a semiconductor container (hereinafter, referred to as a container), Fig. 3 is a perspective view of a semiconductor manufacturing apparatus (hereinafter, referred to as a manufacturing apparatus) in which the opening/closing apparatuses are installed, Figs. 4, 7, and 8 are conceptual

graphs each showing the correlation between the maximum velocity of opening the container and the number of foreign particles adhering to a wafer, Fig. 5 is a conceptual graph showing, relative to change of time, the velocity of opening the container by the opening/closing apparatus according to the first embodiment of the present invention, and Fig. 6 is a conceptual graph showing, relative to a change of time, the velocity of opening the container by the conventional opening/closing apparatus.

Descriptions will be first made of respective structures of an opening/closing apparatus 100 and a container 200 by using Figs. 1 and 2. The opening/closing apparatus 100 is mainly constituted by a stage 110 for placing the container 200, and an opener 120 for holding a lid 220 of the container 200 and for opening and closing the lid 220. The stage 110 is provided with positioning pins 112 for placing the container 200 in a proper position ~~condition~~, and a slider 111 for bringing the container 200 closer to an opener 120 closer to the container 200. In this embodiment, the slider 111 is movable back and forth by a motor and a ball screw (not shown) provided in the stage 110. Rotating keys 121 are provided on the opener 120, and the rotating keys 121 can rotate up to 90 degrees by a motor (not shown) provided in the opener 120. In the rear side of the opener 120, an opener opening/closing mechanism 130 for opening and closing the lid 220 of the container 200 by making the opener 120 move back and forth horizontally, and an opener elevator mechanism 131 for moving the opener 120 up and down are provided. Both of the opener opening/closing mechanism 130 and the opener elevator mechanism

mechanism 131 are operated by a motor and a ball screw (not shown), and a safety cover 140 is provided on the whole of both driving units of the opener opening/closing mechanism 130 and the opener elevator mechanism 131 so that a operator(s) can ~~does~~ not touch them easily.

The container 200 is constituted by a container body 210 and the lid 220. The container body 210 is provided with four latch grooves 211, and a flange 212 is provided around the container body 210. A shelf (not shown) is provided inside the container body 210 for storing wafers 300 horizontally, and twenty-five wafers can be stored therein. Key grooves 221 are provided on the lid 220 at positions corresponding to those of the rotating keys 121 of the opening/closing apparatus 100. The rotating keys 121 of the opening/closing apparatus 100 are inserted into the key grooves 221 and rotated by 90 degrees. ~~and thereby~~ By virtue of this, four latches 222 in the lid 220 come in and out from the lid 220 by a ~~cum~~ cam mechanism (not shown) operating inside the lid 220. The latches 222 are at positions corresponding to those of the latch grooves 211 of the container body 210, and when the latches 222 come out from the periphery of the lid 220 while the lid 220 is inserted in the container body 210, the lid 220 can be fixed to the container body 210.

The actual operation of opening the container 200 is carried out as follows. The container 200 is placed on the stage 110. The slider 111 on the stage 110 is moved horizontally toward the manufacturing apparatus, and a surface of the lid 220 of the container 200 and the opener 120 of the

opening/closing apparatus 100 are contacted to each other. At this time, though the flange 212 of the container 200 and a surface board 150 of the opening/closing apparatus 100 are partly contacted to each other, a gap is inevitably left therebetween due to the process accuracy of the container 200. When the rotating keys 121 are rotated by 90 degrees in the clockwise direction toward the container 200 while the lid 220 and the opener 120 are contacted to each other, the key grooves 221 of the lid 220 are rotated and the lid 220 is fixed to the opener 120. ~~and~~ Simultaneously, the latches 222 ~~is~~ are accommodated inside the lid 220 by a function of the ~~cam~~ cam mechanism (not shown) inside the lid 220. Thereafter, the opener opening/closing mechanism 130 is horizontally moved toward the manufacturing apparatus to detach the lid 220 of the container 200 from the container body 210. Specifically, the lid 220 of the semiconductor container 200 is held and opened in a direction vertical to an opening surface of the container 200. Then, the opener 120 is moved downward by the opener elevator mechanism 131.

The operation of closing the container 200 is carried out in a reverse manner to the operation of opening the same, in which, after the opener elevator mechanism 131 is moved upward, the opener opening/closing mechanism 130 is moved horizontally toward the stage 110 to connect, to the container body 210, the lid 220 fixed to the opener 120. Thereafter, when the rotating keys 121 are rotated by 90 degrees in the counterclockwise direction, the latches 222 of the lid 220 are fit into the latch grooves 211 on the container body 210. ~~and~~ Thus, the lid

220 is fixed to the container body 210. Finally, the slider 111 is moved horizontally in a direction opposite to the manufacturing apparatus, and, thereby, the container 200 is put into a state where it can be detached from the stage 110.

Fig. 3 shows an example where four opening/closing apparatuses 100 are mounted to a manufacturing apparatus 400. Downflow is formed inside the manufacturing apparatus 400, and the inside of the apparatus 400 is kept in the ISO cleanliness level 1 to 2, that is, the inside thereof is kept in a very clean condition in comparison to the outside of the manufacturing apparatus 400 which is in the ISO cleanliness level 6. If a wafer is left in the environment of the ISO cleanliness level 6, ~~then~~ over time foreign particles adhere to a wafer surface ~~with time~~. ~~and thereby~~ As a result, the yield of ~~the~~ semiconductor components formed on the wafer is significantly decreased. The inside of the container 200 is shielded from the outside thereof, and if the wafer 300 is loaded and unloaded in the high-cleanliness environment, the cleanliness inside the container is maintained. Therefore, even if the container 200 is left in the environment of the ISO cleanliness level 6, only a small number of foreign particles adhere to the wafer 300 inside the container 200 unless the lid 220 of the container 200 is opened or closed.

When the wafer 300 is moved from the container 200 to the manufacturing apparatus 400 or from the manufacturing apparatus 400 to the container 200, the lid 220 of the container 200 is opened or closed after connection of the manufacturing apparatus 400 and the container 200 via the container

opening/closing apparatus 100, ~~and thereby~~ Thus, a clean area inside the manufacturing apparatus 400 and a clean area inside the container 200 are directly connected to each other. Since the pressure inside the manufacturing apparatus 400 is set to a slightly positive pressure ~~slightly~~ in comparison to the outside thereof, there is little possibility that the foreign particles will flow ~~there~~in through the gap between the flange 211 of the container 200 and the surface board 150 of the opening/closing apparatus 100, except at the moment of opening or closing the container 200.

If the operating velocity of the opener opening/closing mechanism 130 of the opening/closing apparatus 100 is high, then the inside of the container 200 ~~becomes~~ experiences a negative pressure at the time of pulling out the lid 220 from the container body 210, and the foreign particles enter into the container 200 through the gap between the flange 211 of the container 200 and the surface board 150 of the opening/closing apparatus 100, and adhere to the wafer 300.

Fig. 5 shows, relative to the change with time, the velocity of opening the container 200 by the opener opening/closing mechanism 130 of the opening/closing apparatus 100 according to the present invention. In Fig. 5, the horizontal axis represents time (s) and the vertical axis represents the velocity of opening (m/s), and the maximum velocity is 0.025 (m/s). Fig. 6 shows, relative to the change with time, the velocity of opening the container 200 by the opener opening/closing mechanism 130 of the conventional opening/closing apparatus 100. In Fig. 6, the horizontal axis represents time (s) and the vertical axis represents the

velocity of opening (m/s), and the maximum velocity is 0.15 (m/s).

Fig. 4 is a conceptual graph showing the correlation between the maximum velocity of opening the container and the number of foreign particles adhering to a wafer stored in the container when the inside pressure of the apparatus 400 is higher by 1 (Pa) than the pressure of the outside. In Fig. 4, the horizontal axis represents the maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130, and the vertical axis represents the number of foreign particles (Number/Wafer·Times) which have a grain size of 0.12 μm or more and which adhere to the uppermost wafer 300 stored in the container 200 per opening/closing of the container 200. Fig. 7 is a conceptual graph showing the correlation between the maximum velocity of opening and closing the container and the number of foreign particles adhering to a wafer when the inside pressure of the apparatus 400 is higher by 5 (Pa) than the pressure of the outside. The vertical and horizontal axes of Fig. 7 represent the same ~~things~~ variables as those of Fig. 4. Fig. 8 shows a conceptual graph showing the correlation between the maximum velocity of opening and closing the container and the number of foreign particles adhered to a wafer when the inside pressure of the apparatus 400 is higher by 10 (Pa) than the pressure of the outside. The vertical and horizontal axes of Fig. 8 represent the same ~~things~~ variables as those of Figs. 4 and 7.

In Fig. 4, the number of foreign particles adhering to the wafer 300 exceeds 0.01 (Number/Wafer·Times) at the maximum velocity of 0.06 (m/s), and it rapidly increases ~~at~~ if the maximum

velocity over ~~the~~ 0.06 (m/s). In Fig. 7, the number of foreign particles exceeds 0.01 (Number/Wafer·Times) at the maximum velocity of 0.3 (m/s), and in Fig. 8, the number of foreign particles exceeds 0.01 (Number/Wafer·Times) at the maximum velocity of 0.6 (m/s). As is apparent from Figs. 4, 7, and 8, it can be understood that the maximum velocity, at which the number of foreign particles increases, becomes higher in proportion to the differential pressure between the inside pressure and the outside pressure of the apparatus 400.

The number of foreign particles adhering to the wafer 300 can be reduced by decreasing the maximum velocity of opening of the container by the opener opening/closing mechanism 130. However, the slow operating velocity in each unit of the opening/closing apparatus 100 influences the process faculty of the manufacturing apparatus 400 per unit time. Therefore, it is required to set the operating velocity in an appropriate range. For this reason, it is conceived that the operating velocity should be set in a certain range capable of sufficiently assuring the operation ability of the semiconductor manufacture, and also be set lower than the operating velocity at which the number of foreign particles is 0.01 (Number/Wafer·Times), which is a boundary at which the number of foreign particles adhering to the wafer begins to rapidly increase in all of Figs. 4, 7, and 8. Since the differential pressure between the inside pressure and the outside pressures of the apparatus 400 is proportional to the maximum velocity at which the number of foreign particles begins to increase, the number of foreign particles adhering to the wafer surface can be suppressed by

setting a ratio (velocity-differential pressure ratio Dvp) between the Vmax: maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130 and ΔPa: differential pressure (Pa) between the inside pressure of the apparatus 400 and the outside pressure so as to satisfy the formula 1 shown below.

$$\mathrm{Vmax}/\Delta\mathrm{Pa} = \mathrm{Dvp} \leqq 0.06,$$

where ΔPa: differential pressure (Pa) between the inside pressure of the apparatus 400 and the outside pressure, Vmax: maximum velocity (m/s) of opening the container by the opener opening/closing mechanism 130, and Dvp: velocity-differential pressure ratio (m/s·Pa).

In this embodiment, since the velocity-differential pressure ratio is within the range defined by ~~the~~ formula 1, the number of foreign particles adhering to the wafer 300 stored in the container 200 can be reduced. Therefore, the yield of the semiconductor component can be improved.

Note that this embodiment is an example where the condition outside the container is in the ISO cleanliness level 6, and the number of foreign particles adhering to the wafer changes depending on changes in the surrounding condition. However, the maximum velocity at which the number of foreign particles adhering to the wafer begins to rapidly increase is always constant.

By providing a packing at a contact position between a surface plate 150 of the opening/closing apparatus 100 and a flange 212 of the container 200, and by filling the gap between the surface plate 150 and the flange 212, the foreign particles

which enter into the container at the time of opening the lid 220 of the container 200 are shut out, ~~and therefore~~ Thus, the number of foreign particles adhering to the wafer 300 can be reduced. If the packing is provided, however, the following problems ~~as follows~~ are ~~caused~~ created. That is, one problem is that the packing itself generates dust due to the deterioration caused by the change with time and to repetitive use of the packing. ~~and thereby~~ Thus, there is an increase in the number of foreign particles adhering to the wafer. Another ~~one~~ problem is that the cost is increased due to the additional cost required to provide the packing itself, to process the surface plate, and to install the packing. Since the packing is not required in this embodiment, the reliability is high and the cost is low.

Also, in another embodiment (second embodiment) of the present invention, an opening is provided at a lower end portion of the safety cover 140 of the opening/closing apparatus 100. In the conventional safety cover 140, the opening is provided at only the upper end portion of the safety cover. Therefore, ~~there~~ a problem has arisen ~~such a problem~~ that the foreign particles generated from the opener opening/closing mechanism 130, the opener elevator mechanism 131, or the like are deposited inside the safety cover 140. ~~and that~~ As a result, the deposited foreign particles are blown out at the time when the opener elevator mechanism 131 moves downward, and enter the container 200 and adhere to the wafer. In this embodiment, since the opening is provided at the lower end portion of the safety cover 140, the foreign particles are not deposited inside the safety cover and are not blown out. Therefore, the

number of foreign particles adhering to the wafer 300 stored in the container 200 can be reduced, and thus the yield of the semiconductor component can be improved.

The safety cover 140 covers the driving systems of the opener opening/closing mechanism 130 and the opener elevator mechanism 131 in order to ensure safety of an operator and to protect the driving systems at the time of conveying the opening/closing apparatus 100. Therefore, even if the opening is provided at the lower end portion of the safety cover 140, the safety cover does not lose its essential function.

Also, in this embodiment, the opening is simply provided at the lower end portion of the safety cover 140. However, the same effect can be expected by providing an exhaust fan at the lower end portion of the safety cover 140.

INDUSTRIAL APPLICABILITY

As described above, according to the present invention, it is possible to reduce the number of foreign particles entering into the container at the time of opening the container, and, therefore, the number of foreign particles adhering to the wafer can be reduced and the yield of the semiconductor component can be improved. In addition, since ~~the~~ a packing is not required, ~~the~~ an opening/closing apparatus having high reliability can be realized at low cost.

Also, according to the present invention, since the foreign particles are not deposited inside the safety cover, the foreign particles are not blown out, and, thus, the number of foreign particles adhering to the wafer can be reduced.

Therefore, the yield of the semiconductor component can be improved.

<u>What is claimed is:</u>

1. A semiconductor container opening/closing apparatus, comprising:

a stage ~~for~~ to plac~~ing~~e a semiconductor container accommodating a semiconductor wafer;

a connection portion ~~for~~ to connect~~ing~~ an opening of said semiconductor container and an opening of a semiconductor manufacturing apparatus;

an opener ~~for~~ to hold~~ing~~ a lid of said semiconductor container and then to open~~ing~~ and clos~~ing~~e said lid in a direction vertical to an opening surface of the container; and

an opener elevator mechanism ~~for~~ to mov~~ing~~e down the opener holding the lid of said semiconductor container so as to connect the opening of said semiconductor container and the opening of said semiconductor manufacturing apparatus while both of the openings are opened, or ~~for~~ to mov~~ing~~e up said opener so as to close the connection between said openings,

wherein an operating velocity of opening the container by the opener is set such that a velocity-differential pressure ratio obtained by dividing the maximum velocity at the time of opening the lid of said semiconductor container, by the differential pressure between the inside pressure and the outside pressure of said semiconductor manufacturing apparatus, becomes 0.06 ((m/s) Pa) or less.

2. A semiconductor container opening/closing apparatus, comprising:

a stage ~~for~~ to plac~~ing~~e a semiconductor container accommodating a semiconductor wafer;

a connection portion ~~for~~ to connect~~ing~~ an opening of said semiconductor container and an opening of a semiconductor manufacturing apparatus;

an opener ~~for~~ to hold~~ing~~ a lid of said semiconductor container and then to open~~ing~~ and close~~ing~~ said lid in the direction vertical to an opening surface of the container;

an opener elevator mechanism ~~for~~ to move~~ing~~ down the opener holding the lid of said semiconductor container so as to connect the opening of said semiconductor container and the opening of said semiconductor manufacturing apparatus while both of the openings are opened, or ~~for~~ to move~~ing~~ up said opener so as to close the connection between said openings; and

a cover ~~for~~ to cover~~ing~~ both said opener having moved down and said opener elevator mechanism, and means for preventing particle generated by operation of the opener and opener elevator mechanism from being trapped in the cover, said means including

wherein an opening ~~is~~ provided at a lower end portion of said cover in the rear side of said semiconductor container opening/closing apparatus.

3. The semiconductor container opening/closing apparatus according to claim 2,

wherein an exhaust fan is provided at a lower end portion of said cover in the rear side of said semiconductor container opening/closing apparatus.

4. A semiconductor device manufacturing method, comprising the steps of:

accommodating a semiconductor wafer in a semiconductor container and conveying between each semiconductor manufacturing apparatus;

connecting an opening of said semiconductor container and

an opening of said semiconductor manufacturing apparatus;

connecting said openings such that a velocity-differential pressure ratio obtained by dividing the maximum velocity at the time of vertically opening a held lid of said semiconductor container, by the differential pressure between the inside pressure and the outside pressure of said semiconductor manufacturing apparatus, is set to be 0.06 ((m/s) Pa) or less; and

processing a semiconductor wafer accommodated in said semiconductor container.

ABSTRACT OF THE DISCLOSURE

In the present invention, the problem that When a ~~the~~ conventional semiconductor container opening/closing apparatus opens a lid of a semiconductor container, foreign particles enter into the ~~semiconductor~~ container from outside through a gap between the ~~semiconductor~~ container and a wall surface of the ~~semiconductor~~ container opening/closing apparatus and adhere to a wafer in the container ~~is solved~~. An apparatus is provided to reduce As a result, the number of foreign particles adhering to the wafer is reduced by preventing foreign particles from entering into the container at the time of opening the ~~semiconductor~~ container by the ~~semiconductor container~~ opening/closing apparatus. To achieve this,

~~In the semiconductor container opening/closing apparatus according to the present invention,~~ a velocity-differential pressure ratio obtained by dividing the maximum velocity at the time of opening the lid of the ~~semiconductor~~ container in a vertical direction to an opening of the ~~semiconductor~~ container, by the differential pressure between the inside pressure and the outside pressure of said semiconductor manufacturing apparatus, is set to be 0.06 ((m/s) Pa) or less.